

Transmission enhancement for hetero-structure metal hole arrays

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The optical transmittance of the sub-wavelength holes can be enhanced by arranging them in a periodic array owing to the resonant excitation of the surface plasmon-polaritons (SPPs). In the THz region, however, the transmittance of the sub-wavelength metal hole array is very low compared with that in the visible region because of the extremely short attenuation length of the evanescent mode in the metal holes. In this paper, we investigated the transmission property of the hetero-structure metal hole array and found that the transmission is strongly enhanced.

Figure 1 shows the schematic diagram of the hetero-structure metal hole array (HS-MHA) used in our study. The metal layer with sub-wavelength holes (Layer2, diameter $d_2=0.3$ mm) was sandwiched by two other metal layers with the larger hole diameters (Layer1 and Layer3, $d_{1,3}=0.8$ mm). The spacing between the holes and the thicknesses are $s=1.13$ mm and $t=0.25$ mm, respectively, for all samples. The transmission spectrum of the Layer2 shown in Fig. 2 (dotted line) shows the very low transmittance because of the cutoff frequency of the metal hole at 0.59 THz. The transmission spectrum of the HS-MHA, on the other hand, shows the high transmission peaks at 0.48 THz and 0.28 THz (an enlarged figure is shown in the inset of Fig. 2), which correspond to the resonant frequencies of the second and first order SPPs. From the results of the finite difference time domain simulation, we concluded that such strong transmission enhancement for the sub-wavelength metal hole array is attributed to the enhancement of the electric field of the SPP which is excited strongly at the input surface of the outer layer (Layer1) of the HS-MHA.

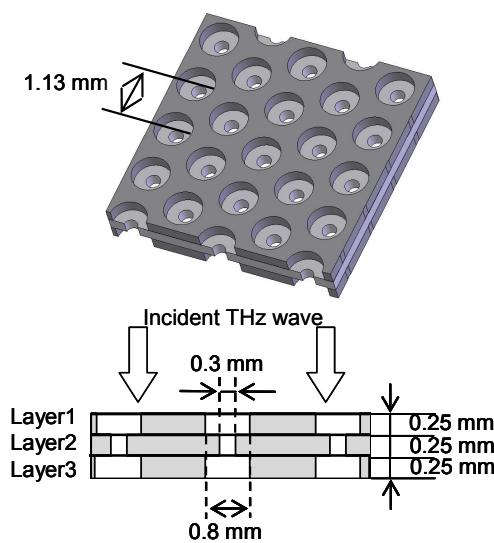


FIG. 1. Schematic diagram of the HS-MHA.

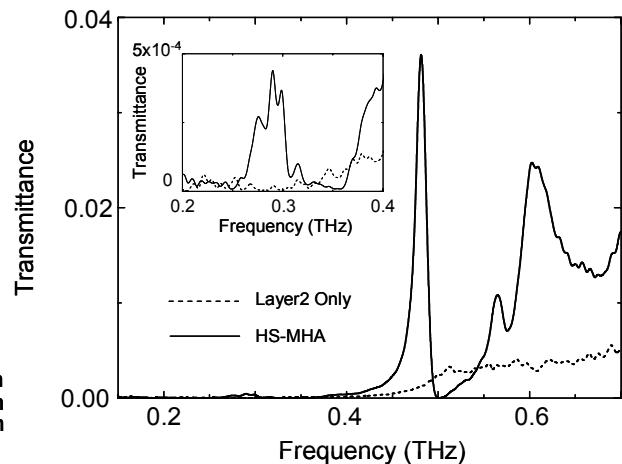


FIG. 2. Measured transmission spectra of Layer2 (dotted line) and HS—MHA (solid line). Inset shows the enlarged figure at around 0.3 THz.